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RESEARCH REPORT

EMPLOYMENT OF TACAIR IN CENTRAL EUROPE:
PROBLEMS AND POSSIBLE SOLUTIONS

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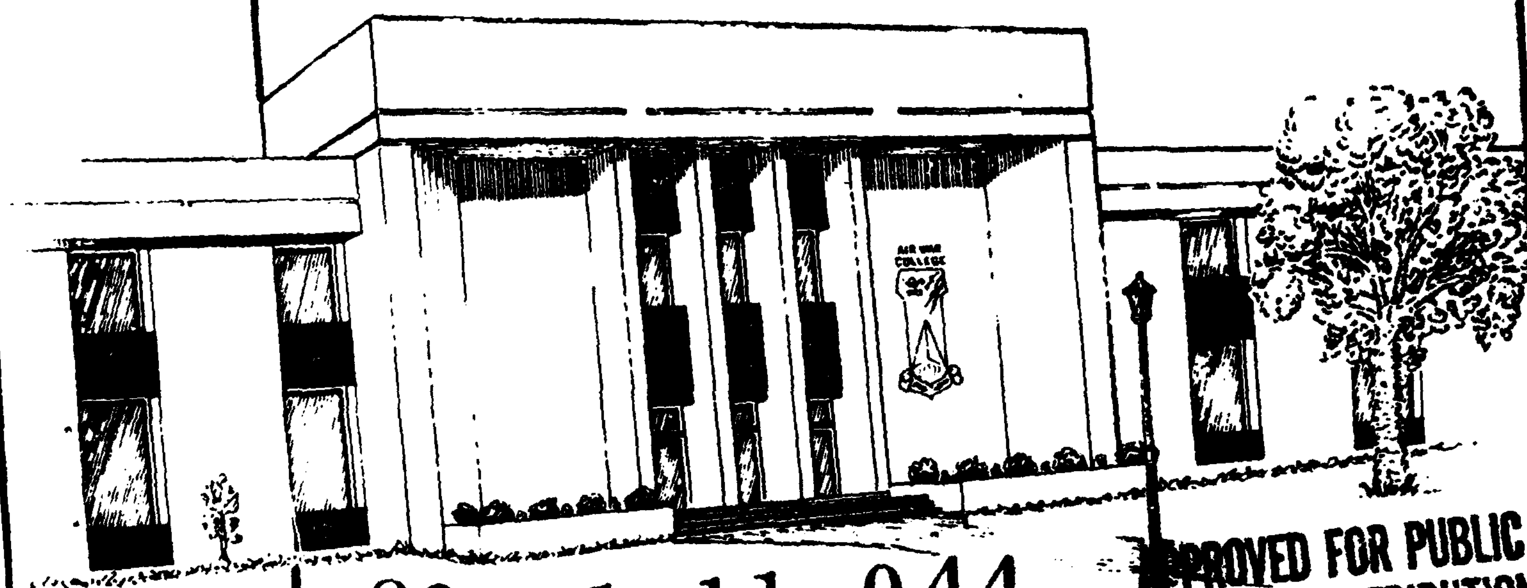

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EMPLOYMENT OF TACAIR IN CENTRAL EUROPE: PROBLEMS AND POSSIBLE SOLUTIONS

by

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AIR WAR COLLEGE RESEARCH REPORT ABSTRACT

TITLE: EMPLOYMENT OF TACAIR IN CENTRAL EUROPE: PROBLEMS AND POSSIBLE SOLUTIONS

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Discussion of the Warsaw Pact threat to the employment of combat aircraft in offensive missions leads to identification of critical areas in the combat efficiency of air power. The vulnerability of air bases and aircraft, and target acquisition are shown as the areas which primarily affect the efficiency of combat aircraft. Current and future approaches to overcome the deficiencies are discussed. Electronic warfare and the suppression of enemy air defenses are seen as means for enhancing the effectiveness of air power as well as alternative options such as RPVs and missiles in supporting functions. The employment of air power is seen as indispensable for Central Europe in the initial phase of an armed conflict as well as in support of the FOFA concept. In the foreseeable future, no effective alternatives to the employment of TACAIR in Central Europe are expected.

BIOGRAPHICAL SKETCH

Lieutenant Colonel Fred Verweinen is a German Air Force officer. As a former pilot, he has been interested in all aircraft and airwar related subjects. After graduating from the German Armed Forces Command and General Staff College, he served in several staff positions in major armed forces and air force commands as well as a military adviser in an institute for science and politics. In 1985, he became assistant head of a section in the Air Staff, Ministry of Defense, in Bonn. Lieutenant Colonel Verweinen is a graduate of the Air War College, Class of 1988.

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CHAPTER I

INTRODUCTION

Experiences from armed conflicts of the recent past have shown that attacking targets by air is an indispensable option in waging a successful war. Today targets in the enemy's rear area can be attacked by flying systems with more efficiency and precision than other systems can provide. For engaging targets in the close vicinity of one's own ground forces the importance of these systems has also been clearly demonstrated. In spite of an increased threat by enemy air defense, the employment of flying weapon systems has been decisive for the results of the recent Middle East wars. But it has also become evident that flying weapon systems can lose their combat effectiveness if new air defense systems emerge that are not yet known in detail.

In addition, there is a trend toward the use of high technology in weapon systems, which is particularly marked in air forces and seems to have reached a peak here. In the course of that development, costs have drastically increased for high performance aircraft. At the same time, however, the efficiency of these systems seems to decrease vis-a-vis a steady increase in the number and effectiveness of enemy air defense systems. Thus, the development of alternative

solutions to enhance the option of weapon employment by air seems to be inevitable.

The specific characteristics of aerial warfare systems--wide range, mobility, flexibility, and ability to penetrate, even if sometimes considerably restricted--permit planning and execution of the employment of air power according to the situation on the battlefield. In the view of the numerical superiority of the Warsaw Pact ground forces these characteristics of air power take on an increased significance in the European theater. In case of a surprise attack or an attack with minimum warning, the air forces are able to take up the defensive battle on the entire width of the frontline immediately, while NATO ground forces are still advancing to their defense positions according to the general defense plan. Thus in the initial phase of an armed conflict, the air forces might play a decisive role (weapon of the first hour.)[1]

In such situations, however, the majority of NATO's air operations has to be executed in a zone of high density air defenses. Since those initial operations can be decisive for the final outcome of the conflict, measures must be taken to allow the employment of air power in areas with high air defense density at tolerable losses or else other options have to be found to perform the required missions.

This paper, therefore, concentrates primarily on those areas which influence the effectiveness of airpower. The purpose of this paper is to point out weaknesses in the employment

of tactical aircraft in offensive missions in Central Europe as well as means and measures to increase the combat effectiveness. Though the problems addressed in this paper are not confined to a European theater of war, the peculiarities of this region render those problems especially crucial.

Due to space limitations, this paper can only touch on the most crucial issues. All areas are covered on a theoretical and conceptual basis and require further scrutiny. It is not meant to be a hardware discussion.

This paper should stimulate considerations for future weapon system developments to be carried out on a more doctrine-oriented and threat-oriented basis. Less glamorous options of weapon employment should not be ruled out in advance.

I will first delineate the threat which is posed by the Warsaw Pact air defense systems to NATO air forces. Then I will try to identify those critical areas which most significantly affect their combat effectiveness and discuss considerations for improvements. Finally, I draw conclusions for force structure and operational concepts from that discussion.

CHAPTER II

THE WARSAW PACT AIR DEFENSES IN CENTRAL EUROPE

For NATO, the problems mentioned gain particular importance in view of the recent improvement in the air defenses of the Warsaw Pact forces. This improvement is marked by an increase in capability and quantity of the air defense systems via the exploitation of new technologies. The Warsaw Pact armed forces increasingly introduce modern, mainly mobile air defense systems. Those systems range from antiaircraft artillery of medium caliber (ZSU-X), to handheld surface-to-air missiles (SA-16) to medium and heavy air defense missile systems (SA-11, SA-12) for all altitudes.[1]

Together with the SA-4, SA-6, SA-7/14, SA-9/13, and the ZSU-23/4, the new systems are employed in close echelons and with a high degree of integration. They are equipped with different kinds of optical or radar-technical target acquisition and tracking systems, thus exploiting a wide range of the electromagnetic spectrum. By their broad engagement zones they permit multiple overlapping of the combat effectiveness areas.[2]

The efficiency of an air defense belt operated according to Soviet procedures, which consisted mainly of SA-6 and the radar-guided, self-propelled antiaircraft system ZSU-23/4, has been strikingly proven in the Yom Kippur War.[3]

However, the weaknesses of the concept of a mobile air defense belt have also emerged. Those weaknesses consisted in

the coordination of the ground based air defense with the employment of fighters or one's own fighter bombers and in the identification of the targets.[4] In the course of the war, the attrition rate of the Israeli combat aircraft could be reduced through the employment of efficient, U.S.-provided electronic countermeasures and antiradar missiles and by use of special tactical maneuvers. Even so, the operational possibilities of the Israeli Air Force remained restricted because of the effective enemy air defense. For the Israeli Air Force, the major threat came from the SA-6 and the ZSU-23/4.

In Central Europe, however, NATO air forces have to prepare themselves for a considerably denser network of air defense systems. These include the most modern weapon developments such as SA-12/13/16 and the ZSU-X. In this region, the Warsaw Pact forces possess the most modern, most faceted and most densely echeloned air defense system in the world. The major threat for NATO combat aircraft, which are to penetrate the enemy air space at low altitude and at high speed, is assumed to come from the ZSU-23/4 or the ZSU-X and the missile systems SA-6/8, SA-9/13 and SA-14/16, which are optimized to engage low flying targets. With the hand-held systems, problems with the acquisition and identification of the targets could arise. These systems, howcver, can be employed in large numbers because of their relatively low costs and can, therefore, facilitate total coverage air defense up to 3,000 feet. In that way, they certainly contribute to the threat to

combat aircraft. They might, however, have more importance for the engagement of attack and support helicopters, as their employment in Afghanistan has already shown.

The comprehensive and multifaceted air defense system is being supported by a network of stationary and mobile early warning posts and command and control centers for the employment of fighters. The introduction of the airborne warning and control system "Mainstay" provides the Warsaw Pact air defense system with increased combat capabilities against low flying targets. The employment of this system together with the current most effective Soviet fighters MIG-31/Foxhound, MIG-29/Fulcrum, and SU-27/Flanker, all of which have a look-down/shoot-down capability, has significantly increased the effectiveness of the Warsaw Pact air defense.

A significant benefit of the increase in density of the air defense network is that the frontal aviation forces have been relieved from air defense operations. This shift from air defense to offensive missions for tactical aviation has been supported by the introduction of fourth generation aircraft which have a considerably increased payload and range.

Besides interdiction missions against the deploying NATO ground forces, Warsaw Pact offensive counter air operations against NATO air bases will be the operational center of gravity for the frontal air armies.[5] Thus, the dense air defense network of the Warsaw Pact not only endangers the offensive operations of NATO air forces but also provides

relief for their frontal aviation from air defense missions and enlarges their capability to hinder the operations of NATO air forces by closing down their air bases.

CHAPTER III

PROBLEMS IN THE EFFECTIVE EMPLOYMENT OF TACAIR IN CENTRAL EUROPE AND POSSIBLE SOLUTIONS

Introductory Remarks

In view of the improvement of the Warsaw Pact air defense network, the question of whether NATO air forces can live up to their assigned roles with current equipment and operational concepts arises urgently. In essence, to what extent can NATO still perform required offensive tasks effectively in the face of the current threat?

The narrowing of the technological gap between East and West and the numerical superiority of the Warsaw Pact forces seriously question the capability of NATO air forces. Budget constraints prevent NATO from balancing the numerical asymmetry. NATO should therefore strive for superiority in important areas of the weapon employment spectrum through reasonable exploitation of new technologies. The number of available weapon systems, however, will eventually play important and often decisive roles.[1] Besides the size of the force, command and control procedures as well as engagement tactics which exploit the weaknesses of the assumed enemy concept are of utmost importance for the outcome of the battle. These C^3I components still offer a large potential for improvements, which could in turn increase the combat effectiveness of NATO air forces.

The foregoing threat analysis shows that NATO air forces in offensive operations will be far more endangered in the future than today. In order to maintain the cost-effectiveness of weapon delivery from the air, improvements in critical areas or new solutions have to be found.

The areas in which the combat efficiency of air forces could be influenced most of all seem to be the following:

- the operational vulnerability of air force formations
- the tactical vulnerability of combat aircraft
- the suppression of enemy air defense (SEAD)
- the problem of target acquisition, which is closely linked to the vulnerability of combat aircraft
- electronic warfare (EW), and
- alternative employment options

Operational Vulnerability

In view of the improvement of the Warsaw Pact tactical air forces within the last few years, the importance of the "operational vulnerability" of NATO air forces is growing. Operational vulnerability is defined here as the vulnerability of air force formations on air bases. The improvement of the Warsaw Pact air forces was characterized by the introduction of modern combat aircraft of the fourth generation, such as SU-24 Fencer, and the evolution of the frontal air armies from a mere close support instrument for the ground forces to a more independent air force. The frontal air armies are now capable

of covering the whole spectrum of air warfare from effective air support to counter air and deep interdiction missions.[2]

In case of an armed conflict, concentrated attacks on NATO air bases by formations of the frontal air armies as well as by bombers of the long range air armies are to be expected. Thus the WP air forces' improvements substantially endanger the capability of NATO air forces, which are still dependent on air bases with long runways.

Striking successes by these air attacks, as achieved by the Israeli Air Force in the Six-Day War, are not expected any more because of the construction of shelters, the deployment of air bases defenses, and the acquisition of rapid runway repair equipment. Regardless, NATO air forces still can be restricted considerably in their operational capabilities by such massive enemy counter air missions.

Though offensive counter air operations temporarily lost significance through the measures taken on both sides after the shock of the Israeli successes in the Six Day War, these missions gained importance again with the development and introduction of new weapons for runways and shelter attacks.[3] Thus, today, counter air missions against airbases again have a high priority in the Warsaw Pact scheme of operations.[4]

Looked at in the short term, this operational vulnerability can be reduced by a more effective air defense, especially by strengthening the air base defenses.[5] In view of the increasing all weather capability of the Soviet combat

aircraft, the deployment of an all-weather system for air base defense becomes urgent.[6]

In the long run the operational survivability of NATO's air forces can be improved by an effort to diminish the dependency of future combat aircraft on long runways.[7] The increased capabilities of the Warsaw Pact tactical air forces to carry out counter air operations have given the preservation of NATO air forces' operational freedom a top priority. In view of the numerical imbalance between NATO and Warsaw Pact air bases in Central Europe, the capabilities of Warsaw Pact air forces are even more significant.[8]

To decrease further the efficiency of enemy counter air operations a larger dispersion of NATO combat aircraft needs to be available. A large number of air bases has to be prepared for operation, that is to be provided with ammunition, fuel, communication, and other support facilities. In addition, highway sections should be prepared to be use as dispersion bases.[9] The operational applicability of this concept is beginning to show in the new generation of combat aircraft such as Tornado, F-16, F-15. These systems have a substantially improved short takeoff and landing capability. This, however, must be supplemented by a corresponding deployment concept.[10]

Whether a vertical takeoff and landing (VTOL) capability should really be demanded for the future generation of combat aircraft seems doubtful, at least for Central Europe.

This region already provides an extensive infrastructure which can be used by the current generation of combat aircraft.[11]

Tactical Vulnerability of Aircraft

Operational vulnerability can be diminished by improving NATO's air defense capability, by new aerodynamic features of future combat aircraft and by using new deployment concepts. Tactical vulnerability on the other hand can be influenced by a series of measures in the area of mission planning and execution as well as in the field of aircraft design.

Generally speaking, the quality of the enemy air defenses and the vulnerability of the combat aircraft determine the attrition rate. The vulnerability of the aircraft depends primarily on the detection and kill probability by the enemy air defenses. The probability of detection has, therefore, to be kept as low as possible or to be influenced by tactics or design accordingly.

A major parameter for the probability of detection is the size of the target. The dimensions of an aircraft influence visual detection as well as radar detection through the corresponding radar cross section. The size of a combat aircraft depends to a large extent on the mission for which it is designed. Thus, a fighter bomber for deep interdiction missions has to feature different dimensions than an air superiority fighter because of the different range and payload requirements.

In general the goal is to design smaller and lighter aircraft by utilizing new technologies and materials for fighter bombers or multi-role aircraft without shortfalls in payload or range. The use of lighter materials such as composites can reduce structural weight and lead to an overall weight reduction. These materials are also electrically non-conductive and will favorably influence the radar cross-section of the aircraft. The electronic stability, which is computer generated and which in contrast to aerodynamical stability decreases the drag, can together with a fly-by-wire system lead to an increase in performance. This among other design factors can influence size and weight of an aircraft. The use of super-critical wings and variable wing geometry (VG) can lead to increase in performance which, in turn, can be exploited for less size and weight of the future combat aircraft. These design features have already partially been applied with the new aircraft generation now being introduced (e.g., Tornado which employs fly-by-wire and VG).

The attempt to increase the survivability of a combat aircraft by augmenting its tolerance against enemy fire seems to be less promising. Through a robust construction, a hydraulic-mechanical steering system, the use of titanium for pilot protection, fireproof tanks, and other protective features, high survivability is supposed to be achieved. As proven by the Fairchild A-10 this concept leads to considerable size and weight and low combat speed. This size of an aircraft

and its combat speed, however, are decisive features for an acquisition by the enemy air defenses. Detection often equates to engagement by the new generation of fire-and-forget missiles. Thus, such a weapon system might only have a limited combat efficiency. Though the majority of the air defense systems use primarily radar, the probability of visual detection remains important. Even all-weather capable systems, such as the SA-8, can be employed optically and engage targets if acquisition and engagement by radar is excluded by electronic countermeasures (ECM). Thus, the small size of the aircraft, a camouflage according to the deployment region, as well as the use of smoke-reduced engines can considerably contribute to reducing the probability of visual detection.

Many air defense missiles, especially hand-held and air-to-air missiles, are equipped with an infrared seeker for target acquisition and engagement. Therefore, the infrared radiation of an aircraft influences its vulnerability to a great extent. Though the employment of infrared missiles requires a visual or radar acquisition for identification, the infrared signature of the aircraft plays an important role in the engagement phase. The strength of that infrared radiation determines if and at what distance the infrared sensor succeeds in getting a lock-on. As the infrared radiation primarily generates from the hot engine parts and the exhaust jet it can only be reduced to a certain extent by design. Thus, tactical

procedures and the employment of decoys, and infrared flares, are required.

Additionally the employment of special tactical procedures or electronic measures can decrease the probability of detection or engagement by enemy air defenses. This can be achieved by trying to over-, under-, or circumnavigate the effectiveness perimeter of the air defense systems. Unfortunately, the densely echeloned Warsaw Pact air defense and the mobility of most antiaircraft systems make it extremely difficult to locate them and thus impossible to circumnavigate the effectiveness zones.

To evade vertically, that is to operate in altitudes above 3,000 feet, seems to be improbable for the Central European theater of war. The prevailing weather conditions, and the efficiency of the Warsaw Pact air defense in medium altitudes[12] nearly exclude an effective employment of combat aircraft according to this penetration concept without supporting forces.

The most efficient tactical measure to avoid early detection by enemy air defense has been proven to be extremely low level flight at high subsonic speeds.[13] The physical and psychic tolerance of combat aircraft crews, the required minimum altitude for terrain avoidance, and the limits of the aerodynamic and mechanical tolerance of combat aircraft, however, restrict the flight envelope considerably.[14] However, the

engagement of a target can often only be carried out if the protecting low level flight is abandoned and the air speed is reduced. Otherwise target acquisition capability is considerably restricted. The protecting factors, low-level flight and high speed, therefore are very efficient during the penetration phase. During the engagement phase they could restrict the efficiency of the combat aircraft considerably by their influence on timely target acquisition and on weapon accuracy.[15]

Electronic equipment for target acquisition and weapon release (such as the constantly computed impact point/CCIP) can permit so-called anti-flak profiles. These profiles make it more difficult for the air defense systems to compute the target parameters and could reduce the hit-probability of some air defense systems considerably.[16] The use of this equipment or the employment of precision-guided munition (PGM) increases the efficiency of the munition used, but it cannot completely solve the dilemma between altitude or speed and vulnerability vs. combat effectiveness.

Tactical vulnerability can be decisively influenced if methods are found to avoid the quasi-optical line of sight between combat aircraft and air defense systems or to hinder the air defense systems to make use of it.

In addition to tactical measures, employment concepts which rely on methods or components for air defense suppression

should be considered. Electronic warfare* also seems to offer solutions as well as new design technologies. These new technologies decrease radar reflection through use of radar absorbing material and a corresponding shape of the aircraft.

The concept of "stealth aircraft" is supposed to reduce the vulnerability of combat aircraft by air defense systems substantially. The possibility of designing a real "invisible" aircraft has to be judged in my opinion rather skeptically because of the limiting facts of physics.

Much emphasis is also put on the attempt to develop weapons which can be employed over long stand-off distances hence avoiding the effectiveness perimeter of the air defense weapons. This concept would degrade the combat aircraft to a mere transport system.[17] Problems concerning reconnaissance and target acquisition, especially that of mobile targets could, however, constrain the realization of this concept.**

Another approach is the development of weapons which can be employed at high speed and at low altitude without the necessity of an early target acquisition. This concept comprises vertically mounted and downward fired missiles, a microwave-radiometer, an infrared sensor, a laser, and a weapon computer. Target acquisition and engagement are carried out

*See p. 27: "Electronic Warfare"

**See p. 23: "Target Acquisition"

automatically. Even targets not recognized by the pilot are engaged.[18]

It appears that tactical vulnerability can only be reduced by a combination of measures effeciently. In the face of the high costs of flying weapon systems, improvements in that area seem to be indispensable.

Suppression of Enemy Air Defense (SEAD)

The possibilities of jamming, deceiving, or destroying the target acquisition and fire-control equipment of air defense systems offer more prospects for decreasing the efficiency of enemy air defenses. Radar-controlled systems can easily be detected by their emissions and allow countermeasures already in the acquisition phase. Air defense systems which are based on passive target acquisition and tracking equipment can only be reduced in their efficiency after firing of their missiles which can be detected visually or by infrared sensors. Then countermeasures such as releasing infrared flares, radiating deceiving emissions, or flying evasive maneuvers can reduce the effectiveness of those air defense systems.

The most efficient measure to eliminate enemy air defenses is the direct engagement and the destruction of their radar antennas, fire control equipment, and their launchers or guns. This method, however, is the most costly and requires specialized aircraft.[19] As a consequence, its employment has to be confined to few areas and combat-deciding situations.[20]

Less costly options are the employment of expendable drones with radar-seeker head (harassment drones) as well as the equipment of fighter bombers with anti-radiation missiles. The expendable drones have a passive seeker head and a small conventional warhead. They are launched in areas where offensive air operations are to be executed. Their seeker-heads try to lock on the radars of air defense systems and use their emissions as terminal guidance. Should the drones miss radar emissions, they fly programmed patterns until the sensor is able to lock on an activated radar. The warhead is designed to destroy a radar antenna. An early engagement of the drones by the air defense systems is possible but not very likely because of their small radar cross section. Mobile launchers enable the employment of drones out of positions close to the FEBA.[21] This concept requires close coordination between the fighter bombers and these supporting systems.

To equip fighter bombers with anti-radiation missiles would integrate the suppression of enemy air defense into the actual mission. This would also yield the advantage that the suppression of enemy air defenses could be limited to the actual operation area. Unfortunately only radar-controlled air defense systems could be reduced in their efficiency. To cover the whole spectrum of the air defense threat, other measures and means are indispensable.

Expendable drones with high radar reflection which could be employed as decoys offer another option. These drones

should mask combat aircraft and saturate the air defense systems. By a special mounting of radar reflectors, their radar signature resembles that of combat aircraft. Air defense systems could be deceived and caused to engage these decoys. The following combat aircraft could then benefit from the limited reloading capacity of the air defense systems. In Central Europe it seems to be doubtful that a saturation of the air defenses or a decisive lack of missiles could be achieved by that concept. One can assume a large reloading capacity of the Warsaw Pact air defense formations. It also cannot be excluded totally that the fire control operators will not rise to the bait because of the speed and the flying characteristics of those decoys, and that engagements will not be executed.[22]

Even if employed, this concept also can only reduce the efficiency of radar-guided systems. Thus, high speed and low altitude and the use of infrared flares are to be employed in addition to increase the survivability.

For air operations in the deep interdiction area, the combination of fighter-bombers and systems for enemy air defense suppression has to be supported by additional forces. The tasks of air defense are then executed to an increasing extent by fighters. The self-defense capacity of fighter-bombers could reach their limits during such operations so that deep interdiction or deep counter air missions probably require forces comprising fighter escorts, defense suppression aircraft, and EW aircraft. The increased capability of Warsaw

Pact fighters to acquire and engage low flying targets (look-down/shoot-down capability) has put such deep operations at an even greater risk. This fact is gaining attention because the attack of the second echelon forces of the Warsaw Pact is considered to be of decisive importance for the European theater of war (follow-on-forces attack/FOFA).[23]

It has to be stated that suppression of enemy air defense has become an indispensable prerequisite for air operations above enemy territories with high air defense density, as it is the case in Warsaw Pact territory.

The Middle East experience of 1982, has shown that a solution of the defense suppression problem may be found in a broader range of military means including remotely piloted vehicles, electronic countermeasures, airborne stand-off weapons, evasive tactics and even surface-to-surface missiles and tanks.[24]

Target Acquisition

Reconnaissance provides crucial information about the potential or actual enemy in case of war. This, in turn, forms the basis for the decision process of the commanders. Reconnaissance is an indispensable prerequisite for a reasonable and effective employment of armed forces. In respect to the offensive employment of combat aircraft, current reconnaissance reports can also contribute to the exploitation of gaps in the

enemy air defenses and thereby increase the combat aircraft's survivability.

Current reconnaissance is not only a prerequisite for correct positioning of own forces but also a preliminary stage of a fast and direct target search and location. Prerequisite for an effective target engagement is, however, the target acquisition by the combat aircraft themselves. Developments in this field strive for an integration of reconnaissance, target acquisition, and engagement.

The engagement of ground targets from the air is first of all a problem of target acquisition. The context is obvious. Bettering one's own target acquisition also favours the target acquisition by the enemy so long as a line of sight is a prerequisite for a target engagement. Besides survivability, target acquisition ability determines the combat effectiveness of air warfare means. The improvement of target acquisition has, therefore, become an important research and development field.

Approaches to a solution of this problem may be found in following areas:

- In increased coordination and cooperation within the framework of the offensive air support organization. (This, however, is only possible in close proximity to the FEBA)
- In autonomous procedures, which base on electronic target acquisition equipment, and

- In coordinated procedures with remotely operating target acquisition systems.

The increased cooperation with the army can improve the target acquisition but is not without problems. The still practiced conventional method has some major deficiencies. By a "forward air controller" (FAC), the target is acquired visually. The FAC guides the combat aircraft onto the target. The disadvantage of this procedure is obvious. In Central Europe lines of sight which allow a target acquisition beyond the reach of the guns of tanks or APC's are scarce. Thus, the FAC is often endangered by enemy fire. If the FAC is forced to use indirect control, target acquisition has to be performed by the pilot thus increasing the exposure time of the aircraft to the enemy air defense in locating the target.[25] Besides that, the aircraft have to be controlled by radio. Thus, the enemy is able to jam the communication by jamming.

Even if the FAC uses devices for target designation (e.g., laser) the problems remain the same. Target marking, however, enables the combat aircraft to acquire and engage the target with a high probability of success. Here the aircrews are relieved completely from their own target acquisition. By utilizing such a procedure, the efficiency of combat aircraft in the vicinity of the FEBA can be improved significantly.[26]

To diminish the problems of mobility and the restricted visual range of the FAC, they often operate with helicopters or light aircraft. Even this requires close proximity to the

enemy forces which threaten the survivability of the FAC. In this case better target acquisition has been traded off by higher attrition of the supporting system.

Another approach to solving the problem of target acquisition is equipping the combat aircraft with target acquisition equipment. The spectrum of this equipment ranges from stabilized lens systems, TV-cameras, laser, and radar to infrared sensor and display systems. Some of these systems also provide night and adverse weather attack capability.

These target acquisition systems, however, do not relieve the combat aircraft from operating in relatively close proximity of the targets. Either the sensor range or the low level flight restrict the pilot in establishing a quasi-optical line of sight to the target at greater distances.

Procedures with autonomously operating target acquisition systems might attain greater importance. Improvements in the field of radar (using new "special windows" with greater resolution) or the employment of unmanned air vehicles seem to offer solutions. Target marking with laser by ground elements (e.g., FAC) or airborne platforms (e.g., drones or RPVs), relieves aircrews completely from their own target acquisition. It requires, however, close coordination and secure communications. All these procedures do not solve the problem of target location and acquisition in principle. The problem is only turned over to a supporting system.

Simple and effective solutions for the problems of target acquisition do not exist. Compromises with satisfactory efficiency can only be achieved at relatively high costs in the combat aircraft[27] or with supporting systems. Then, however, the combat effectiveness depends to a large extent upon the ability to coordinate and even more importantly to communicate.

Electronic Warfare[28]

Electronic Warfare (EW) has gained a special importance in conflicts between air forces employing high technology weapon systems.[29] Modern air forces are dependent upon the employment of electronic means of all kind: central command and control of the air forces over long distances require electronics for communication. The inherent advantages of air power, like speed of reaction, flexibility in application, and concentration on target can only be fully exploited in this way. Navigation, target acquisition and identification as well as target engagement are supported by electronic components. The degrading of their functioning by means and procedures of electronic warfare can directly diminish or even abolish the combat effectiveness of the weapon systems.

The efficiency of EW depends on the ability to prevent the potential enemy from exploiting the electromagnetic spectrum. Efficient EW, therefore, requires intimate knowledge of the electronic means and measures employed by the enemy. Thus in preparing for combat, the first task is "to find and

identify the enemy's electronic order of battle." (12:305) Electronic warfare has become a main component of air wars and an advantage in this field seems to grant a successful campaign even if the enemy is numerically superior.[30]

The employment of EW measures by combat aircraft are, however, restricted by a number of factors. Space and payload restrictions have to be taken into consideration. EW equipment together with other protective measures like air-to-air missiles are carried at the expense of the combat payload.[31] Thus self-protection, through sufficient amounts of radar warning, jamming, and deceiving equipment, is limited. The self-protection concept has therefore to be supported by threat-oriented tactical procedures.*

An alternative or supplement to the self-protection concept is the employment of escort or stand-off jamming. Due to the variety of air defense systems this task can be performed most efficiently by ground based systems or by highly sophisticated specialized airborne systems. These systems are very expensive and therefore constitute critical resources for the employment in Central Europe.[32]

The development of procedures and hardware for electronic warfare depends on relatively exact knowledge of the enemy's weapon systems and procedures. This intelligence

*See p. 12 "Tactical Vulnerability"

dependency of electronic warfare is twofold. On the one hand there is a need to know the current enemy systems to develop one's own countermeasures; on the other hand, there is a need to anticipate new enemy weapon systems to be able to react on short term with one's own hardware or procedure developments. Otherwise in the case of a conflict, the loss of time to adapt or procure equipment and also the incorrect assessment of the enemy's capability could result in a "technological surprise."[33] Thus, just in the initial phase of an air war there is a great danger that high attrition rates have to be accepted or that certain weapon systems cannot be employed at all.

Thus, even at high expenses and with the employment of new technologies, uncertainties remain. Measures of electronic warfare may not always ensure the success of the operations. Nevertheless, they remain indispensable in modern air warfare and can possibly just make the difference.

Alternative Employment Options

Unmanned air vehicles seem to be a cost-effective alternative to manned combat aircraft. The absence of a pilot or an aircrew renders a lot of supporting systems (like oxygen supply, ejection seat, etc.) unnecessary and abolishes some restrictions given by the physical and psychological tolerance of man. The absence of man, however, leads to the fact that in combat phases which require a decision, human possibilities of intervention have to be established or human decisions have to

be preplanned and reproduced by computers.[34] The first requires sensors and reliable, unjammable communications links. The second requires sensors and complex computer programs to process all given data immediately.

By that we have pointed out the most distinct features between the both types of unmanned air vehicles: RPVs (remotely piloted vehicles) and drones or cruise missiles. RPVs remain during their mission under real-time control of a remote pilot, whereas drones and cruise missiles execute their missions by preloaded programs.

Although RPVs are generally more expensive because of their sensors and electronic equipment for communication, they are reusable. Drones for tactical use (like harassment drones) are normally cheaper and often expendable. Both are relatively small and therefore hard to detect. The radar cross-section is very small, and the use of synthetic material contributes to that advantage, too. Their infrared signature and sound emission can also be kept very low.

The mentioned characteristics of unmanned air vehicles seem to allow the conclusion that a broad spectrum of missions could be covered at low costs which are at this time assigned to manned aircraft or other systems.

Studies of the German Air Force and experiences of the German Army have indicated various problems which seem to make large-scale employment of RPVs and drones in multiple missions improbable. Some of these problems are:

- the jam-resistance of the necessary communications with real-time remotely guided systems
- the landing or rescue procedures for reusable systems
- the accuracy of weapon delivery for autonomously operating systems
- the low payload capacity for conventional missions
- the high costs of sophisticated and accurate expendable systems like cruise missiles in conventional missions.

The employment of unmanned air vehicles seems to be restricted because of these problems to the following operational spectrum:

(1) Operations at high altitude during long periods with the following tasks:

- theater of war surveillance
- communications and electronic intelligence
- battlefield surveillance

(2) Operations at low level in especially dangerous operation areas with the tasks

- battlefield reconnaissance
- air defense suppression/counter air defense
- electronic warfare
- attacks of strongly defended stationary targets
- target acquisition and designation

The development of unmanned air vehicles for air reconnaissance is advanced most and offers some operational options in Central Europe. Several systems are already being employed in that region.[35]

The employment of so-called harassment drones against radar-guided air defense systems seems to be very promising. Here the advantages of unmanned systems are exploited consequently without having trade-offs by the disadvantages. The anti-radar drone is hard to detect, has a long loiter-time, and carries a warhead which is able to destroy radars.* These drones are an ideal supplement to other weapons such as the AGM-88A HARM which has to be employed by an aircraft.

Thus, unmanned air warfare systems offer solutions which could only be achieved by other weapon systems at higher costs. But as pointed out, they can only supplement, not replace, manned systems at the current stage of development. A concept in which unmanned systems take over clearly defined roles and missions of the operational spectrum can lead to a a considerable reinforcement of air forces at reasonable costs.[36] Future air forces will certainly be comprised of a mix of manned and unmanned systems, as some already do. The more intensive employment of unmanned systems will, however, not revolutionize the air war in the foreseeable future.

*See page 20 "Suppression of Enemy Air Defense"

Cruise missiles are a valuable enrichment of the arsenal of tactical or strategic nuclear weapon systems. For employment in the tactical-conventional realm these missiles still have deficiencies. They can currently only be employed against stationary targets and can carry only a relatively small warhead, which is unable to destroy most of the targets efficiently. The circular error probable (CEP) is reported to be between 10 and 30 m which is not precise enough for pinpoint targets when taking into account the small warhead. Furthermore, cruise missiles might also be too expensive for tactical targets, "even if they could be made sufficiently accurate."[37]

Similar restrictions apply to ballistic missiles and artillery. These weapon systems are restricted in their mobility. They still have a large CEP and little payload, and can therefore hardly be employed against mobile battlefield targets. Multiple rocket launchers can cover ranges up to 40 km and be equipped with terminally guided submunition. They seem to offer better options for the close-in battle. Though restricted in mobility all these systems could support the missions of manned and unmanned aircraft. They could, above all, "release manned aircraft from operations against heavily defended targets."[38] and from dangerous attacks against enemy air defenses.[39]

Thus, the contribution of these systems to air warfare will be restricted and confined to specific situations and mainly supporting functions.

CHAPTER IV

TECHNICAL AND OPERATIONAL CONSIDERATION

The discussed technical and tactical possibilities have shown that there is no simple or completely new approach or concept to improve the efficiency of offensive air warfare. It also turned out that many solutions require a future oriented threat analysis and long-term planning. Some of these options imply great insecurities in respect to their combat effectiveness and often represent a high financial risk. That applies especially to solutions which are based on changes in the design features of combat aircraft (e.g., stealth technology, VTOL).

A trend to transfer functions from the aircraft to supporting systems or to the weapon itself can be identified. In this approach, tasks such as target acquisition or designation are carried out by supporting systems. This approach, however, produces a penalty in the form of coordination or heavy dependency on communications. By that the enemy has new possibilities to reduce the effectiveness of these systems considerably.

Even if there is a lot of optimism in respect to further technological progress, the considerations of the technical and tactical options for the engagement of targets on the ground seem to prove that airpower will remain irreplaceable in the near future.[1] The tactical environment, however, makes it

increasingly more difficult to maintain the efficiency of combat aircraft. The consequences which result from that fact for the design of aircraft, the supporting elements and for the employment concepts of air forces are multifaceted.

The equipment of air forces in the Central European region has to be oriented towards the greatest threats, the tactical and operational vulnerability, and the most important target arrays which are armoured vehicles of the Warsaw Pact and its airbases. That means that the dependency of combat aircraft on long runways and their detectability as an air target have to be reduced. The capability to engage tanks and attack air bases has to be increased. For tank engagements, single pass-multiple kill capability is indispensable to reduce the exposure time of aircraft to the enemy air defenses, which, even with effective suppression, can never be eliminated entirely. The number of tentative airbases and a respective deployment concept, as well as the number of combat aircraft, their size, their radar, and IR profile and effective munitions gain increasing importance.

Thus, the future combat aircraft of the Central European battlefield should possess short-field take-off and landing capabilities in order to increase the number of usable airfields. Low radar profile and infrared signature could reduce the vulnerability during the missions. A wide spectrum of weapons, especially for tank and airbase attacks, could ensure the required flexibility.

The great dependency of NATO on the combat effectiveness of its air forces emphasizes the importance of its air forces and the necessity to deploy combat aircraft, which are capable of carrying out their missions even under the worst conditions autonomously supported by jam resistant navigation and target acquisition systems and weapons.

This inevitably will lead to very complex and expensive weapon systems. The high costs of these combat aircraft determine the missions. Missions against armoured formations of the Warsaw Pact are thus only reasonable in the depth of the battlefield. There, tanks and other armoured vehicles are still concentrated on roads, in assembly areas and at choke points such as bridges, etc. Unlike as on the battlefield where tanks operate dispersed, here entire formations can be attacked in a single pass with area munition such as scattered mines and tank busting submunitions.[2]

Thus, deep interdiction as well as counter air missions are to be considered the main tasks of these weapon systems. This priority, however, does not preclude that in critical phases of a conflict necessary air support for the ground forces has to be carried out.[3] That is especially true for the initial phase of a conventional war in Central Europe, in surprising break-throughs by the enemy or under adverse weather conditions which render the employment of other means impossible or to have a limited effective.

The high costs of combat aircraft imply the danger of drastically reduced sizes of the air forces. This may lead to a concentration of forces on few bases and to an increase of the imbalance between NATO's offensive systems and the enemy defensive systems in air operations. This would be a very detrimental trend for the overall force balance in Central Europe. The argument that superior western quality could balance the superior eastern quantity cannot be held up for air forces any longer.[4] For the missions in question, the duel between aircraft and air defense is decisive, not the duel of fighter vs. fighter.[5] The variety and multitude of the Warsaw Pact air defense systems cause considerably more problems for the NATO aircraft than Warsaw Pact aircraft will have to overcome in the HAWK and PATRIOT defense belts and the fewer organic air defenses of the NATO ground forces. The policy of technological sophistication of single weapon systems at the expense of the size of the total force could be detrimental for the combat effectiveness of the air forces in a confrontation with a numerically superior enemy.

To halt that tendency other aspects and effectiveness criteria have to be considered in the design of aircraft and in the development of employment concepts. These have to take into consideration the complexity of the combat situation as well as tactics, battle management, training, weapons effectiveness, sortie rates, deployment concepts and the dynamics of a future air war.[6] Some of these factors are beyond a quanti-

fiable assessment, but may determine the combat effectiveness of air forces to a greater extent than the measurable superior performance data of the single weapon systems.

Tactics and supporting components gain importance. Superior air battle management and tactics which exploit weaknesses in the enemy force posture and electronic warfare can further compensate for numerical inferiority. Especially electronic warfare will be an essential, often decisive, element of future air warfare. However, employment concepts should not be based on a successful EW as a "conditio sine qua non," because the success of EW is always questionable. Electronic means and measures could be rendered ineffective by less complex but effective countermeasures. Even in those situations, air power has to be employed with sufficient effectiveness. Technology, tactics, and supporting components have to supplement each other.

Thus, considerations for employment concepts cannot be confined to the combat aircraft even though they will constitute the core of tactical air forces for the foreseeable future. Combat aircraft are still forced to penetrate enemy air defenses because of the characteristics of their weapons; thus, they will, to an ever greater extent, be forced to secure their survival. This can be reached by supporting on-board systems and special tactics or by separately operated support systems in various roles.

Supporting systems and weapons with stand-off capability gain increasing importance.[7] All of these can ensure the survival and effectiveness of combat aircraft and can eventually relieve the performance requirements for aircraft which often cause high costs without an equivalent pay-off.

CHAPTER V

EVALUATION AND CONCLUSION

It can be stated that the option of weapon employment from the air is indispensable for Central Europe because of lacking alternatives.[1] In the conventional phase of a war this option can--for the time being--only be carried out by manned aircraft on a larger scale.[2] Other weapon systems have supporting functions in some missions. Especially in the new concept of AirLand Battle, the deep battle will depend heavily on firepower provided by aircraft.[3]

In striving to reduce the vulnerability of aircraft and increase their effectiveness, several approaches have to be pursued. New technologies in aircraft construction often enable only limited increases in efficiency. The improvements are often confined to the aircraft and do not offer better operational qualities. New technologies should, therefore, only be considered if they lead to an actual increase in combat effectiveness. Technological sophistication does not always pay off in mission effectiveness.

A rather selective approach is recommended in this field to prevent a further reduction of aircraft numbers. Technological innovations have to be examined carefully in respect of their tactical value. Combat aircraft have to be designed with regard to the required mission and the expected threat rather than to what can be achieved technologically.[4]

A more comprehensive approach for the design of "weapon systems" is required. The harmonizing of the aircraft design with the weapon development under the consideration of the changing threat and employment conditions is important.[5]

Another important approach to retain the combat effectiveness of aircraft is the protection against enemy air defense. The spectrum of means and measures is broad. It embraces systems and subsystems for electronic warfare, for suppression of enemy air defense and for target acquisition and designating as well as operational and tactical procedures. All of these are to diminish the enemy impact on one's own air operations. Given the current Warsaw Pact capabilities in air defenses, the means and procedures for enemy air defense suppression have gained a high priority. By that, the necessary operational freedom for offensive mission can be regained. Target acquisition is another priority for increasing mission effectiveness. The autonomous acquisition, identification, and engagement of battlefield targets in low altitudes seems to be a promising approach.[6]

In the long run, however, an autonomous stand-off capability will gain greater importance.[7] A realization of this principle which could render aircraft a simple weapon carrier has to be considered a technological breakthrough which has considerable consequences for the entire force structure and the importance of air forces. For the time being, all alternatives to the combat aircraft for offensive missions, such as

ballistic missiles, RPVs, drones or cruise missiles, suffer from deficiencies in mobility, target acquisition, payload and precision for conventional missions. As long as these problems are not solved, these weapon systems are limited in their efficiency or restricted to the employment of nuclear warheads.[8]

The necessary investments in research and development for these systems, however, have to compete with improvement programs for combat aircraft which imply less financial risks. This may be the main obstacle for a broader approach to more combat effectiveness which utilizes the capabilities of other options for air power employment. Even though unmanned systems may play an increasingly important role in supporting offensive missions, the combat aircraft will probably be indispensable for most offensive tasks especially in implementing the AirLand Battle concept in Europe.[9] In view of the resource quandaries, and the vital importance of air power for Central Europe, NATO planners can ill afford to ignore other, perhaps cheaper options of air power employment which may offer superiority on the battlefield of tomorrow.

NOTES

CHAPTER I (Pages 1-3)

1. This assertion is not indisputable. Hans Goebel maintains that, "in the first hours the lack of ground forces cannot be compensated for by air forces" and "the attack aircraft's role would then be reduced to ground support, a task for which it is far too expensive." (7:51)

NOTES

CHAPTER II (Pages 4-7)

1. In "Aircraft, Strategy and Operations of the Soviet Air Force" a detailed description of the systems deployed by the Warsaw Pact in Central Europe and their assumed employment can be found. (5:262-268)

2. The density of the Warsaw Pact battlefield air defense and the overlapping of the different combat effectiveness zones is impressive and can only be fully grasped if graphically shown. This is done very well in "Soviet Military Power." (8:74)

3. Both systems turned out to be a "nasty" surprise for the Israeli Air Force. The Israelis had no electronic countermeasure equipment for the SA-6 missile's radars. The high fire power of the ZSU-23/4 also caused the loss of a significant number of Israeli aircraft. For a detailed discussion see "Air Warfare in the Missile Age." (4:143-172)

4. In "Lessons for NATO From the Yom Kippur War," B. Latter assumes that nearly 60 Arab aircraft have been downed by their own air defense. Even today, however, this figure is not indisputable. (18:380-385)

5. These operations could be supported by the Soviet Rocket Forces," which would strike NATO airfields with mobile surface-to-surface missiles (SSMs)." (31:1620)

NOTES

CHAPTER III (Pages 8-34)

1. Several authors warn about the over-emphasis of technology being able to offset larger numbers. H. Rowen, e.g., states: "A technological lead is extremely useful, but size of forces still matter a great deal. The winner of the future, as in the past, will often be the side that runs out of weapons and troops second." (10:524)

2. Armitage and Mason state in their assessment of Soviet Air Power: "Most improvements were incremental, [but] their accumulative impact has been to transform the Soviet Air Force from their previous concentration on tactical offensive support, air defence and relatively short-range air mobility to a military instrument which could threaten the Western alliance's base areas and reinforcement routes. . . ., while at the same time offering traditional close air support to . . ."

3. There are several developments which again allow efficient counter air operations against airbases. The German cluster bomb MW-1, which can be loaded with submunitions for runway or shelter attack, the French runway-bomb "Durandel," and the British JP-233 are some examples. (24:3-5)

4. "The aims of an air operation . . . can be attained through: destruction of aircraft and aircrew on airfields . . . ." (5:70)

5. The defense of air bases is a complex problem encompassing active and passive defense. While active defense comprises shortrange air defense (SHORAD) and other regional air defenses such as HAWK or PATRIOT-batteries, passive defense implies a number of measures to protect the airbase from an enemy attack or to increase the airbase's survivability after an enemy air attack, such as sheltering, camouflage, deception and dispersion. In "Defense of NATO's Airbases" the present situation of the NATO countries in the Central Region is delineated. (20:134-144)

6. By the deployment of the Franco-German air defense missile system ROLAND II at German air bases and USAFE airbases in Germany this gap is being closed soon. (29:16)

7. Already in 1979, General Pauly, then Commander Allied Air Forces Central Europe (COMAAFCECAAFCE), stated during a symposium: "A whole new concept for a STOL-V/STOL

fighter-bomber is needed . . . We must reduce our reliance on 8000-foot runways." (19:26)

8. The Warsaw Pact has about 560 airbases at its disposal (300 Soviet airbases West of Ural, 90 in Poland, 80 in East Germany, 60 in Czechoslovakia, and 30 in Hungary), whereas NATO only operates about 200 airbases. This leads to a ratio of about 3:1 in favour of the Warsaw Pact. (28:127)

9. In Germany several highway section have already been tested to be used as auxiliary operational airfields. The German Air Force, the Royal Air Force Germany, and the U.S. Air Force Europe have participated in such operations.

10. In spite of the fact, that "about 230 airfields capable of operating advanced jet aircraft have been identified in NATO's Central Region" (20:134) only a few have actually been prepared for combat operations.

11. Despite the numerous problems linked to the VTOL-deployment concept, Bingham makes a strong case for VTOL-aircraft, because "the flexible takeoff and landing characteristics unique to V/STOL aircraft make increased basing survivability possible by dramatically increasing one's ability to exploit measures such as dispersion, mobility, concealment, and deception." (17:53) These measures, however, could also be exploited, if NATO would make more use of already existing deployment possibilities. Bingham even suggests that, "base survivability [should be made] a key factor in determining what aircraft characteristics are required." (17:52)

12. It is not only that nearly all air defense systems can engage targets in altitudes between 3000 feet and 15000 feet most efficiently, this area also constitutes an optimal operation zone for radar controlled interceptors.

13. To accommodate its pilots to altitudes around 100 feet or even less, the German Air Force has established a training command in Goose Bay, Canada, where all fighter bomber pilots perform training flights with TORNADO, F-4F and ALPHA-JET once a year.

14. This flight envelope, which ranges from 0.8 to 0.9 Mach speed and from below 100 feet to 200 feet altitude, can often only be used with modern avionics (e.g., terrain following radar).

15. If a target has to be acquired visually, high speed and low altitude are of great disadvantage. Rudel, the most successful German pilot in WWII concerning tank kills,

found "that the biggest problem was acquiring a tank and that speed was 'poison for finding tanks'." (11:60)

16. The efficiency of anti-flak-profiles, however, is restricted to those air defense systems, the employment of which requires the computing of a lead angle (anti-aircraft artillery) or of a collision point (missiles with command guidance).

17. Air Marshal Knight describes this trend in "Air Power in the NATO Alliance" as follows: ". . . the manned aircraft may increasingly become the carrier, positioner and final releaser of weapons of ever greater stand-off capability, and extreme agility may be built into the weapon rather more easily than into the aircraft." (1:95)

18. This so-called VEBAL-system (vertical ballistic) is being developed by MBB in Germany and seems to be a promising approach to relieve the dilemma between target acquisition and altitude, and by that between combat effectiveness and vulnerability. This weapon also provides a single pass-multiple kill capability. (17:5)

19. A more recent test of this concept as well as of the EW-capabilities, was the Libyan raid by the U.S. Air Force and U.S. Navy in April 1986: "The U.S. SAM suppression effort proved effective. . . . the U.S. encountered heavy activities from SA-2, SA-3, SA-6, and SA-8 systems and seems to have been very successful in suppressing them" and "U.S. electronic warfare systems proved highly successful even though the U.S. carefully kept many technical secrets in reserve for a defence against a Warsaw Pact attack." (22:94, 95)

20. In those situations the capacity of the USAFE is to be used, which has to be coordinated by AAFCE. The special systems of the U.S. Air Force (F-4G/Wild Weasel) can reduce the efficiency of enemy air defenses considerably. By 1990, the German Air Force will have a corresponding capacity at its disposal with the introduction of the ECR-Tornado (Electronic Combat and Reconnaissance). (18:1-12)

21. This concept is being pursued by the German Air Force. The "Kleindrohne Antiradar" (small drone anti-radar) is supposed to be employed accordingly.

22. When the Israelis, however, attacked air defenses, especially SA-6s in the Beeka'a Valley during their 1983 operation "Peace for Galilee" they commenced their attack with a wave of remotely piloted vehicles (RPV), which were launched as decoys, and succeeded in deceiving the Syrians. The Syrian fire control operators "showed poor target

discrimination and firing discipline, and initiated a massed launch of SAMs against the incoming drones." (1:130) This, however, could not be expected from supposedly better trained operators of the Warsaw Pact air defense forces.

23. Unfortunately, SACEUR's new concept has generated an interservice struggle about whose responsibility this mission should be rather than which systems could and should be employed most efficiently. (12:378)

24. The employment of tanks and infantry by the Israelis in their operation "Peace for Galilee" for the suppression of enemy air defense, however, must be considered in the context of the special situation of the Beeka'a Valley and does not constitute a viable option for the European theater of war. (12:337, 1:130)

25. This problem is addressed by Mark A. Barrett, who gives a FAC's perspective on the Close Air Support debate: "When a FAC must use indirect control because of his inability to get in a position to actually observe enemy positions, A-10s or any other CAS aircraft must be in the target locations longer to locate, identifying and then attack targets. This increased exposure severely cuts into the survivability of the CAS aircraft." (26:6)

26. Even these improved possibilities of target engagement in that area have not prevented the questioning of the efficiency of close air support missions. The air defense threat, which is the highest in that area, is assumed to cause a high attrition rate, which renders those missions hardly cost-effective. Thus, several air forces have already turned over that mission to the attack helicopters of the armies. (30:79)

27. The costs for systems like PAVETACK (FLIR system) and LANTIRN (Low Altitude Navigation and Targeting Infrared for Night) are booming. Most air forces cannot afford such expensive systems and even the U.S. Air Force might have problems to procure enough systems to equip all their attack aircraft. (1:25)

28. A detailed discussion about the development of ECM-procedures and hardware can be found in "Air Warfare in the Missile Age." (4:227-230)

29. The USAF puts great emphasis on electronic warfare: "Electronic combat is, and will continue to be, a key element of USAF warfighting capabilities." (12:307)

30. This view is shared by the USAF, which along with the Israeli Air Force has the most actual experience on Electronic Warfare: "Today it would be fatal for a nation to try to fight an air war without a viable electronic warfare capability . . ., electronic capabilities will determine the effectiveness of the force." (12:304)

31. This trend could influence the effectiveness of combat aircraft on target: "The need for self-protection means that an increasing part of the payload must be devoted to air-to-air missiles, defence suppression systems, and ECM-pods." (1:158)

32. The USAF already operates systems like the EF-111 and can therefore apply both concepts: "Today's aircrew must depend on TAC's support systems, such as the EF-111, Compass Call, and F-4G 'Wild Weasel,' to neutralize, suppress, and kill and on self-protection equipment and tactics to defeat the end-game engagement. Both electronic combat support and self-protection are keys to survival while putting bombs on the target." (12:304)

33. The Israeli Air Force ran into such a surprise: ". . . they [the Israelis] did not expect them [the SA-6's and ZSU-23/4] to produce a qualitative change in force balance . . . because their combined technological and tactical impact was seriously underestimated" (2:122) and "The Israelis had no effective ECM to its frequency agility and the combination of very high-speed flight, continuous wave target illuminator, pulsed radar trackers and optional optical guidance made it a very difficult weapon to detect at or after launch." (2:127)

34. Many authors argue that this can neither be done cheaply nor efficiently, and submit, as e.g., Air Marshal Knight in "Air Power in the NATO Alliance," that "man is the most efficient and flexible control device you can install in an aircraft." (1:195)

35. "Fully operational reconnaissance RPVs [in my definition, however, drones] are in service only with the armies of West Germany, Great Britain, Italy, and France (all use the Canadair CL 29), Belgium (Epervier) and Israel (Scout, Mastiff)." (13:74) The German Army is just about to introduce a new model, the Canadair/Dornier CL-289 drone, which "provides surveillance and target acquisition within an army corps area of responsibility." (13:74)

36. In "Unmanned Systems for NATO" James J. Townsend puts it this way: "In conjunction with manned aircraft . . ., unmanned systems can serve as a force multiplier and provide a genuine high/low mix of expensive and cheap weapons systems to

meet numerically superior enemy forces without breaking the budget." (13:72)

37. These doubts are shared by many authors. In "Manned and Unmanned Aircraft" Air Marshal Armitage states: "But even if cruise missiles could be made sufficiently accurate to deliver conventional warheads on to small targets with extreme precision, the relatively small payload and the inherent vulnerabilities in an automatic system would make them a very expensive system indeed in terms of their operational capability." (1:197)

38. Sometimes it is even asserted that [these systems] "Would act as a force-multiplier for conventional air power [in the Central Region]." This assertion, however, overlooks the fact that army weapon systems will in the first place be employed against targets which threaten the ground forces. Furthermore the necessary coordination could restrict these employments to only very specific situations. (1:202)

39. The Israelis employed artillery and surface-to-surface missiles in that mission very successfully during their operation "Peace for Galilee": "SAM battery sites were not only under ground force artillery range but within the range of our new family of computer-guided surface-to-surface missiles; in advance of direct attacks we used long-range artillery." (4:184) However, this was a very special operation within a limited area [Beeka'a Valley] and with very limited forces. The applicability to the European theater of war requires further scrutiny.

NOTES

CHAPTER IV (Pages 35-40)

1. Especially in the concept of the AirLand Battle Group Captain Garden maintains that "The roles carried out by aircraft in the past are going to be needed in the future . . . Offensive air power will continue to provide firepower on scale not otherwise available. It will be on call to redress the balance when the ground battle goes badly. It will attack targets beyond the reach of ground forces." (1:167)

2. Here the question about the effectiveness of precision-guided-munitions (PGM) vs. area munitions arises: whereas PGMs require a separate pass for each kill, the employment of area munition such as MW-1 provide the aircraft with a single pass-multiple kill capability, enhanced by area denial munitions, which hampers the movement of tanks prior to the removal of the scattered mines. (24:3)

3. Without entangling too much into the close air support debate, it can be stated that aircraft such as TORNADO or F-15, F-16, do not constitute the first choice for Close Air Support. In normal combat situations, the attack helicopters may be best suited for this mission. A large amount of controversial literature about that issue exists. For one critical detailed discussion about the problem of fixed-wing aircraft in close air support missions, see Bingham's "Dedicated, Fixed-Wing Close Air Support--A Bad Idea." (11:58-62)

4. Already in 1979, Steven L. Canby stated: ". . . the notion that numerical superiority in combat forces can be offset by technological superiority is in fact self-defeating over the long run." (27:33) This statement is still true today and of considerable importance in regard to our offensive capability vs. the defensive capability of the Warsaw Pact forces.

5. We tend to compare the numbers of aircraft and air defense system of both NATO and the Warsaw Pact. The comparison of the NATO offensive systems vs. the WP defensive systems could convey a more realistic assessment of our offensive capabilities: "The air attack forces of NATO would face a 7 to 1 superiority of Warsaw Pact air defense systems," not counting the numerous hand-held systems. (28:132, translated)

6. Though this paper is focused on technology and tactics, the important role of men, training, and morale should not be forgotten. Well trained aircrews supported by respective ground crews only make a weapon system perform effectively. The interdependence between training and tactics is pointed out by Nordeen: "Through training, ideally the crew melded with the aircraft into an integral team of man and machine, whose performance is honed to a fine edge through tactics. Training and tactics therefore, play an interrelated role: training to achieve proficiency in tactics, while tactics themselves often evolve from vigorous training" and "frequently it has been demonstrated in air warfare that skill, aggressiveness, and tactics can overcome superior numbers and quality." (4:209, 210)

7. This is emphasized by the efforts NATO puts into the development of new weapon systems which embrace stand-off capabilities. In "Attacking Targets Beyond the FEBA" Mark Hewish gives a fairly detailed report about the different new systems under development, often as joint ventures. He asserts, that ". . . emerging technologies will allow NATO to extend its conventional stand-off capabilities." (31:1054) But his report also indicates that most of the new systems are still in the phase of research and development and will not enter service very soon.

NOTES

CHAPTER V (Pages 41-43)

1. In 1979, General Jones, the Chairman of JCS, stated in an interview with General Steinhoff, former Chief of Staff of the German Air Force: "The unique capabilities of manned aircraft in tactical as well as in strategic terms, cannot be replaced by missiles, whether cruise or ballistic." (23:27) This statement is still true today.

2. In "Military Power and the Advance of Technology" Deitchman describes this option in more detail: "Tactical aircraft are still the most flexible means to amass heavy firepower on short notice and bring it where it is desperately needed; to carry firepower deep into enemy territory when that is appropriate; to shift attacks rapidly from one form of target to another and from one location to another as the situation demands; . . ." (3:64-65)

3. The importance of aircraft in offensive operations within the AirLand battle concept is emphasized in "The AirLand Battle": "The manned aircraft will remain a necessary, and irreplaceable part of the firepower available to the ground forces for as far into the future as we can see. Ground-based weapons will improve . . . Nevertheless, fast reacting air power will remain the crucial reserve for reversing the situation in the land battle." (1:159)

4. B. Lambeth brilliantly analyzed this common tendency to confuse technical sophistication with mission-effectiveness: "The greatest problem with technical determination, however, is its tendency to produce statements of 'need' based more on the outer limits of what is technologically feasible than on what performance spread is actually called for by most real mission demands" and "technical sophistication is no more a guarantee of mission effectiveness than sheer numbers unaccompanied by the requisite competence at exploiting it." (21:96, 98)

5. The simultaneous development of the TORNADO and the respective ordnance (MW-1 dispenses and submunition) may be regarded as such a positive approach, which, however, remained an exception. (24:3-4)

6. This approach is pursued by the German corporation MBB. The VEBAL-system acquires, identifies, and engages targets autonously. (17:5) See also Note 18, Chapter III.

7. "The solution to that dilemma (i.e., the vulnerability of combat aircraft) must lie in tactics that hold aircraft outside of the most effective defences yet permit the use of multiple, highly accurate, and flexible weapons. A change from the past emphasis on platform performance and on to weapon performance therefore seems not only inevitable but imperative." (6:46) This view, however, is rather parochial and does not take into account the considerable difficulties to realize an actual stand-off capability for the engagement of tactical-size targets.

8. The assertion brought forward by many authors that not "technical, tactical, or operational obstacles" are the largest obstacles to a greater employment of unmanned systems cannot be shared in view of the delineated restrictions. (13:75) Some even go so far to assert that (for pilots) "it is an article of faith that a manned aircraft can perform any mission better than an unmanned aircraft." (6:646)

9. This assumption is supported by a number of authors who maintain that air power assets are vital for NATO in defense of Europe: "The manned aircraft will remain a necessary, and irreplaceable, part of the fire power to the ground forces far as far into the future as we can see." (1:159)

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GLOSSARY

AAFCE	Allied Air Forces Central Europe
APC	Armoured Personnel Carrier
AWX	All Weather
CCIP	Constantly Computed Impact Point
CEP	Circular Error Probable
CM	Cruise Missile
COMAAFCE	Commander Allied Air Forces Central Europe
ECM	Electronic Countermeasures
ECR	Electronic Combat and Reconnaissance
EW	Electronic Warfare
FAC	Forward Air Controller
FEBA	Forward Edge of Battle Area
FLIR	Forward Looking Infrared
FOFA	Follow-on Forces Attack
GAF	German Air Force
HARM	High Speed Anti-Radiation Missile
IR	Infrared
km	Kilometer
LANTIRN	Low Altitude Navigation and Targeting Infrared for Night
m	Meter
MBB	Messerschmidt-Boelkow-Blohm
MW-1	Mehrzweckwaffe 1 (Multi-purpose weapon-1)
NATO	North Atlantic Treaty Organization
PGM	Precision-Guided Munition
RPV	Remotely Piloted Vehicle
SA	Surface-to-Air
SAM	Surface-to-Air Missile
SEAD	Suppression of Enemy air Defense
SHORAD	Short Range Air Defense
SSM	Surface-to-Surface Missile
USAFE	U.S. Air Force Europe
VBW	Vertikale Bordwaffe (Vertical onboard weapon)
VEBAL	Vertical Ballistic
VG	Variable Geometry
VTOL	Vertical Take-off and Landing
WP	Warsaw Pact